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⑭発明の名称　複雑屈折率分布を有する光ファイバの製造方法

⑳特　願　平1−148503

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明　細　書

1.発明の名称

複雑屈折率分布を有する光ファイバの製造方法

2.特許請求の範囲

(1) 高純度石英系ガラス管の外側に、外付け法により前記ガラス管の屈折率よりも低い屈折率のガラス微粒子層を堆積させ、次いでこのガラス管を均一加熱炉内に収容し、管内に内圧をかけつつ前記ガラス微粒子層を透明ガラス化し、しかるのち管内にコアークラッド型の透明な石英系ガラスロッドを挿入してロッドーインーチューブ法によりファイバ化することを特徴とする複雑屈折率分布を有する光ファイバの製造方法。

3.発明の詳細な説明

(産業上の利用分野)

この発明は、分散フラットファイバのような複雑屈折率分布を有する光ファイバの製造方法に関

従来のこの種のファイバの屈折率分布とえば第5、6、7図に示すものが知られていしてこれらの場合、中心コアおよびその外置する高屈折率部分における屈折率の調整にGeO_2をドープすることで行い、両者の間折率部分における屈折率の調整は純粋SiO_2くはSiO_2にFをドープすることで対応して

しかしながら、その製造方法はいずれのおいても基本的にコアとなる透明ガラスロ回りに外付け法により順次所定の屈折率、厚さを有するガラス微粒子層を積層させ、このガラス微粒子層を透明ガラス化してプームとなし、このプリフォームを一端から引きして所望の複雑屈折率分布を有するフとするものである。

(発明が解決しようとする課題)

ところがこの方法では屈折率の異なる各

の分散特性にばらつきが生じるという問題があった。また、得られるファイバの特性は最終プリフォームの状態になって始めて判断しうるため、製造途中で不具合であっても最後まで作るということになってしまい生産性の点で問題があった。

（課題を解決するための手段）

この発明は、以上の観点から分散特性の安定したこの種ファイバを生産性良く得る方法を提供するもので、その特徴とするところは高純度石英系ガラス管の外側に、外付け法により前記ガラス管の屈折率よりも低い屈折率のガラス微粒子層を堆積させ、次いでこのガラス管を均一加熱炉内に収容し、管内に内圧をかけつつ前記ガラス微粒子層を透明ガラス化し、しかるのち管内にコアークラッド型の透明な石英系ガラスロッドを挿入してロッドーインーチューブ法によりファイバ化することにある。

なお、この発明において、ガラス管内に内圧をかけつつ、その回りに形成されたガラス微粒子層を透明ガラス化するのは、その際の加熱によってガラス管が半径方向および長さ方向に収縮め設定した寸法が狂い所定の径比が得られるのを防止するためである。高純度石英系管内に内圧をかける手段としては、例えば管の開放端の一方を閉じるか、もしくは絞り細孔になし、他方からAr等のガスを通込むなどが挙げられ、その際のガラス管内圧とその回りに加えられる炉心管内圧との差圧の程度はガラス管の軟化温度が1400～1550℃程度の場合、20 mmaq程度とされる。

（作用）

最外層のみを外付け法により得るとともにその外付け法により得られたガラス微粒子層のガラス化に際しては、ガラス管を均一炉内にて、ガラス管内に内圧をかけつつ行うようにので全ての層を外付け法で形成することに法制御性の低下、ならびにガラス管の収縮に寸法のズレが防止され予め設定したとおりのとなる。

（実施例）

内径15 mm、外径20 mmのGeO_2ドープSiO_2（Δ＝0.2％）の高純度ガラス管を60 rpmで回転させつつ、このガラス管に直接して酸水素バーナを対峙させ、バーナ内にH_2 10 ℓ/分、O_2 18 ℓ/分、$SiCl_4$ 400 cc/分、カーテンガスとしてArを800 cc/分供給させつつ、ガラス管の軸方向に沿って20 mm/分の速度でトラバースさせて、SiO_2からなるガラス微粒子層を積層させて外径100 mmとした。このガラス微粒子層が形成されたガラス管を第1図に示す装置を用いて脱水、透明ガラス化した。図において、1はGeO_2ドープSiO_2ガラス管、2はその上に形成されたSiO_2からなるガラス微粒子層である。そして、ガラス管1の一方の開放端は後述するガラス微粒子層2の透明ガラス化のために予め酸水素炎で加熱されてつぶされている。3はガラス管1内に内圧をかけるためのガス供給管でバイパス4を備えてい

るためにガラス微粒子層2よりも十分に長い体7を備えている。8は発熱体7内に位置する石英炉心管で、一端は閉じられ、他端には蓋取付けられており、この蓋9の中心口にガラス1が挿通されて、ガラス微粒子層2を有するガス管1が石英炉心管8内に収容される。10は石英炉心管8の側面に設けられたガス供給口、11は石英炉心管8の一端に設けられたガス排出口である。

以上の構成において、炉心管8内にガス供給口10から塩素ガスを供給するとともにその内温度を1000℃に維持して1時間熱処理してス微粒子層を脱水した。次に石英炉心管8内ガス供給口10からHeガスを流すとともにその温度を1650℃に上げた。一方、ガラス管にArガスを供給して管内圧力を20 mmaqに維た。2時間後ガラス管1を取出したところ、

方予めＶＡＤ法により若干のクラッド部を持つＧｅ型で、コアとなる部分の直径が１０ｍｍおよび比屈折率差Δが0.8 %の GeO_2 －SiO_2ガラス、クラッドとなる部分の厚さが1.5 mm、コアとなる最外部の屈折率との比屈折率差が −0.4 %のＰドープSiO_2ガラスロッドを用意した。そして透明ガラス化を終え炉内から取出された前記ガラス管１内にこのロッドを収容し、両者の隙間にSF_6を１ℓ／分、O_2 5００cc/分流しながら外部から酸水素炎で加熱して溶融一体化して光ファイバ母材とした。得られた母材の屈折率分布を測定したところ第２図のごとくであった。この母材を一端から溶融線引きして直径１２５μｍのファイバとしたところ第３図に示す広帯域で低分散のファイバが得られた。またその損失波長特性を調べたところ第４図に示すように低損失のものであった。

因みに、従来の方法で第３図に示す程度にまで広帯域で低分散のファイバを得るためにはプリフォームを３～４本つくって初めて得ることができる。

（発明の効果）

この発明は、以上のように複雑屈折率分布を有するファイバを得るに際し、出発部材として高純度ガラス管を用意し、寸法制御の困難なガラス微粒子層の形成はこのガラス管の回りの層だけとし、その透明ガラス化に当たってはガラス管が縮しないように管内に内圧をかけつつ行うようにしたので、寸法制度の優れた母材が得られ、従って分散特性に優れたファイバを得ることができる。

また、この発明方法によると寸法制度の優れた母材を高確率で得ることができるので歩留り向上し、以って生産性の向上を図ることができるという副次的効果が得られる。

4.図面の簡単な説明

第１図はこの発明の方法の一行程を示す図、第２図は、この発明の方法によって得られた光ファイバ母材の屈折率分布図、第３図は、この発明の方法によって得られた光ファイバの分散特性図、第４図はこの発明方法によって得られた光ファイバの損失波長特性図、第５～７図は複雑屈折率分布ファイバの屈折率分布図。

特許出願人　　藤倉電線株式会社
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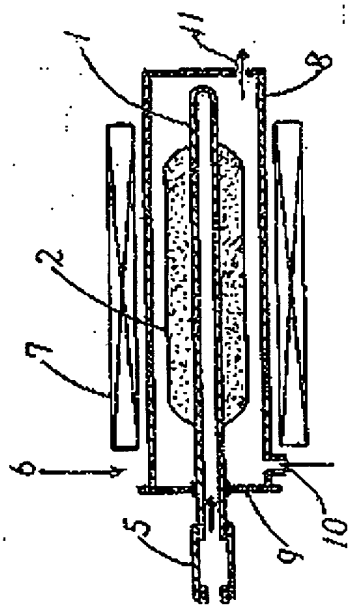
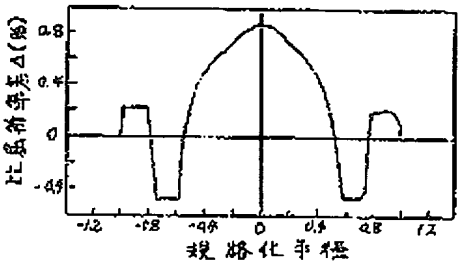
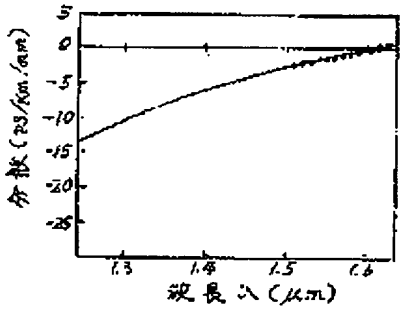
第１図



第２図



第３図



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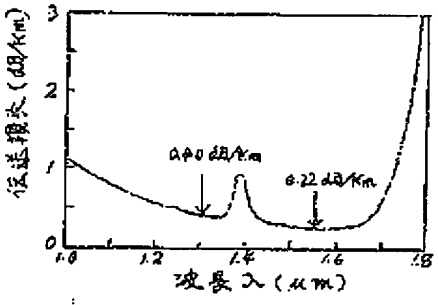

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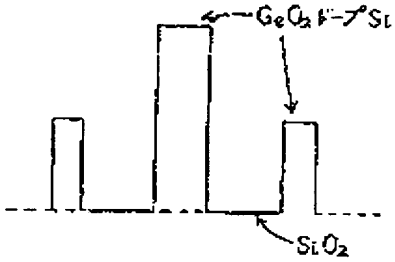
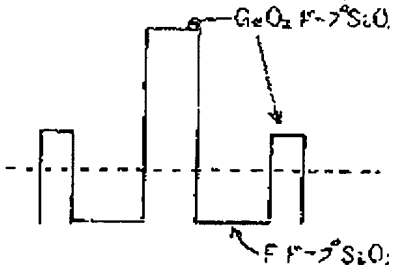
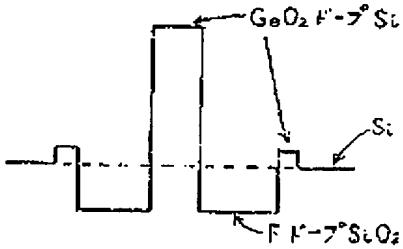


第６図



第７図



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(54) METHOD FOR PRODUCING OPTICAL FIBERS HAVING COMPLEX REFRACTIVE INDEX DISTRIBUTIONS

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CLAIMS

Method for producing optical fibers having complex refractive index distribution, characterized by the fact that on the outside of a highly pure quartz glass tube, a microparticle layer of glass with lower refractive index than the refractive index of the above glass tube is deposited by an exterior application method, this glass tube is then placed inside a uniformly heated oven, and while applying pressure inside the tube, the above glass microparticle layer is made into transparent glass, after which a core-clad-type transparent quartz glass rod is inserted into the tube and made into fibers by the rod in tube method.

DETAILED EXPLANATION OF THE INVENTION

INDUSTRIAL FIELD OF THE APPLICATION

This invention concerns a method for producing optical fibers having complex refractive index distribution such as dispersion flat fibers, designed to improve optical characteristics and improve reproducibility.

PRIOR ART

For refractive index distributions for these kinds of fibers in the past, those shown in Figures 5, 6 and 7 are known. In these cases, the adjustment of the refractive indices in the central core and the high refractive index portion located outside of this is accomplished by doping GeO_2 in SiO_2, and the adjustment of the refractive index in the low refractive index portion between the two is handled with pure SiO_2 or by doping F in SiO_2.

However, these manufacturing methods all successively deposit, by an exterior method, glass microparticle layers having prescribed refractive indices and prescribed thicknesses around a transparent glass rod that will ultimately become the core, then make these glass microparticle layers into transparent glass to make preforms, and then into the desired fibers having complex refractive index distributions by melt-drawing these preforms from one end.

PROBLEMS TO BE SOLVED BY THE INVENTION

With these methods, however, since the various glass layers of differing refractive indices are formed through glass microparticle layers, there are problems: it is not necessarily easy to

make their thicknesses to be those prescribed due to fluctuations in bulk density and fluctuations arise in the dispersion characteristics of the fibers obtained. Moreover, because the characteristics of the fibers obtained can only be evaluated in the final preform state, there is a problem of producibility in that even if there are problems during production, manufacture must be completed.

MEAN TO SOLVE THE PROBLEMS

From the above standpoints, this invention presents a method for obtaining these kinds of fibers with stable dispersion characteristics and good reproducibility. It is characterized by the fact that a microparticle layer of glass with lower refractive index than the refractive index of the above glass tube is deposited by an exterior application method on the outside of a highly pure quartz glass tube, this glass tube is then placed inside a uniformly heated oven, and while applying pressure inside the tube, the above glass microparticle layer is made into transparent glass, after which a core-clad-type transparent quartz glass rod is inserted into the tube and this is made into fibers by the rod-in-tube method.

The reason that, while applying pressure inside the glass tube, the glass microparticle layer formed around it is made into transparent glass in this invention is to prevent the glass tube from contracting in the radial direction and longitudinal direction as a result of heating during this which would warp the dimensions established beforehand and would make it impossible to obtain prescribed radius ratios. As a means for applying pressure inside the highly pure quartz glass, for example, closing one of the open ends of the glass tube or making it with small pores by constriction and sending in Ar gas, etc. from the other end can be cited. The degree of difference in pressure between the pressure inside the glass tube and the pressure in the oven core tube placed around it should be about 2-20 mmaq when the glass tube softening temperature is around 1400-1550°C.

FUNCTION

In addition to obtaining only the outermost layer by exterior application methods, because in making the glass microparticle layer into transparent glass, the glass tube is placed in a uniform oven and pressure is applied inside the glass tube, the decreased dimensional controllability due to formation of all of the layers by exterior application methods and the dimensional fluctuations due to contraction of the glass tube are prevented, and the fibers become exactly as established beforehand.

APPLICATION EXAMPLES

While rotating at 60 rpm a highly pure GeO_2-doped SiO_2 glass tube (Δ = 0.2%) of 15 mm internal diameter and 20 mm external diameter, an oxyhydrogen burner was placed perpendicular to this glass tube, and while supplying H_2 at 10 L/min, O_2 at 18 L/min, $SiCl_2$ at 400 cc/min and Ar as curtain gas at 800 cc/min into the burner, was made to traverse along the axis of the glass tube at a speed of 20 mm/min to deposit a glass microparticle layer consisting of SiO_2 to an external diameter of 100 mm. This glass tube with the formed glass microparticle layer was dehydrated and made into transparent glass using the device shown in Figure 1. In the Figure, 1 is the GeO_2-doped SiO_2 glass tube, and 2 is the glass microparticle layer made of SiO_2 formed on top of this. One of the open ends of glass tube 1 has been heated with an oxyhydrogen flame beforehand and collapsed for making the glass microparticle layer 2 into transparent glass as described below. 3 is a gas supply tube for applying internal pressure in glass tube 1 and is equipped with bypass 4. 5 is a connector which connects this gas supply tube 3 and the open end of glass tube 1. 6 is a uniformly heating oven and is equipped with heater 7 that is sufficiently longer than glass microparticle layer 2 to uniformly heat glass microparticle layer 2 in the longitudinal direction. 8 is the quartz oven core tube attached to heater 7, one end of which is closed. The other end is fitted with lid 9. Glass tube 1 is inserted in the central opening in this lid 9. Glass tube 1 having glass microparticle layer 2 is placed inside quartz oven core tube 8. 10 is a gas supply port located on the side of quartz oven core tube 8. 11 is a gas exhaust port located at one end of the quartz oven core tube 8.

In the above configuration, chlorine gas was supplied into oven core tube 8 from gas supply port 10 while maintaining an internal temperature of 1000°C to heat-treat for 1 hour and dehydrate the glass microparticle layer. Next, He gas was allowed to flow into quartz oven core tube 8 from gas supply port 10 while raising the internal temperature to 1550°C. Meanwhile, Ar gas was supplied into glass tube 1 to maintain the pressure inside the tube at 20 mmaq. When glass tube 1 was removed 2 hours later, the SiO_2 glass microparticle layer 2 had been completely turned into transparent glass at a thickness of 15 mm. Moreover, glass tube 1 had not contracted; it retained the initial internal diameter.Meanwhile, an F-doped SiO_2 glass rod in a GI form having a small clad portion was prepared beforehand by the VAD method with a core GeO_2-SiO_2 glass portion, 10 mm diameter and with a difference in specific refractive index D of 0.8%, and a clad portion, 1.5 mm thick with a difference in specific refractive index of -0.4%, from the refractive index of the outermost portion of the core. This rod was placed inside the above glass tube 1 after turning into transparent glass and was removed from the oven. $SF_{[illeg.]}$ at 1 L/min and O_2 at 500 cc/min were made to flow into the space between the two. This was heated from outisde with an oxyhydrogen flame and melted and unified to form optical fiber base material. When the

refractive index distribution of the base material obtained was measured, it was as shown in Figure 2. When melt-drawing was performed from one end of this base material to form fibers of 125 μm diameter, fibers of low dispersion in the broad region shown in Figure 3 were obtained. When their loss wavelength characteristics were investigated, they had a low loss, as shown in Figure 4.

Incidentally, with the prior methods, fibers of low dispersion in as broad a region as shown in Figure 3 could only be obtained by making 3-4 preforms.

EFFECT OF THE INVENTION

Because this invention has been made so that when obtaining fibers having complex refractive index distributions as above, highly pure glass tubes are prepared as starting materials, and the formation of glass microparticle layers, the dimensions of which are difficult to regulate, is limited to the layer around this glass tube, and turning this into transparent glass is accomplished while applying pressure inside the tube so that the glass tube does not contract, base materials of excellent dimensional regulation are obtained, thereby making it possible to obtain fibers of excellent dispersion characteristics.

Moreover, because base materials of superior dimensional regulation can be obtained with high probability with the method of this invention, the yield improves, thereby obtaining a secondary effect that reproducibility can be improved.

BRIEF EXPLANATION OF THE DRAWING

Figure 1 is an explanatory figure showing an example of the method of this invention. Figure 2 is a refractive index distribution graph for optical fiber base material obtained with the method of this invention. Figure 3 is a dispersion wavelength characteristics graph for optical fibers obtained with the method of this invention. Figure 4 is a loss wavelength characteristics graph for optical fibers obtained with the method of this invention. Figures 5-7 are refractive index distribution graphs for complex refractive index distribution fibers

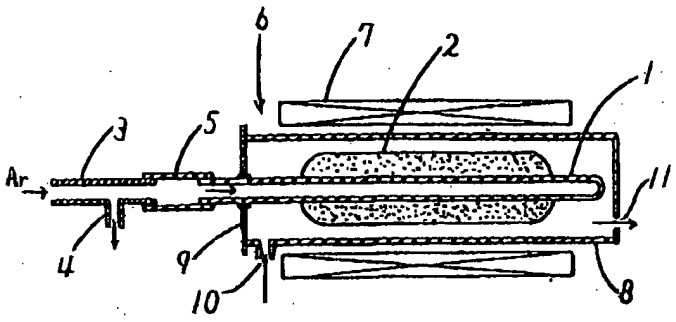


Figure 1

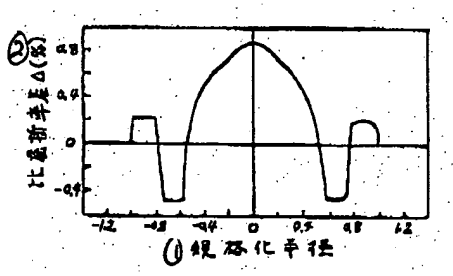


Figure 2

Key: 1 Normalized radius
2 Difference in specific refractive index Δ (%)

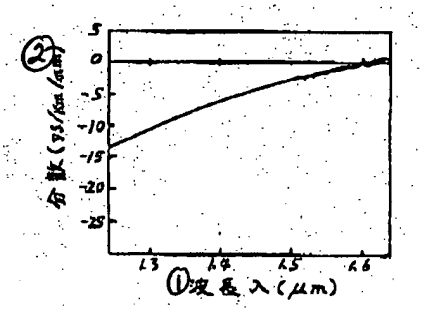


Figure 3

Key: 1 Wavelength l
2 Dispersion

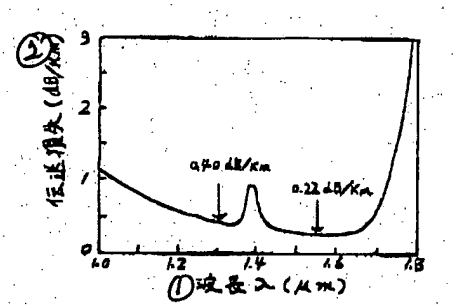


Figure 4

Key: 1 Wavelength l
2 Transmission loss

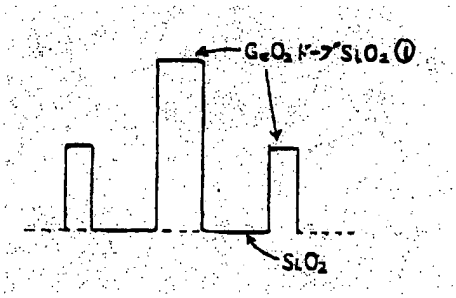


Figure 5

Key: 1 GeO_2-doped SiO_2

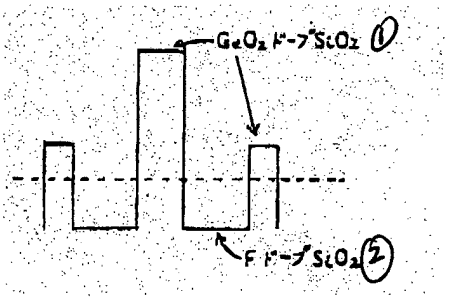


Figure 6

Key: 1 GeO_2-doped SiO_2
2 F-doped SiO_2

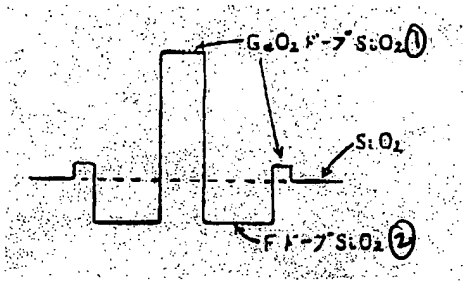
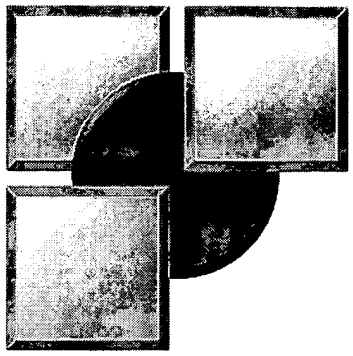


Figure 7

Key: 1 GeO_2-doped SiO_2 glass
2 F-doped SiO_2 glass



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